ENGINEERING DESIGN FILE

EDF No.: 9455 EDF Rev. No.: Project No.: 23415 FCF and/or FDC No.: N/A

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*4. NPH PC or SDC: or ☒ N/A	SSC Safety Category: or ☒ N/A
*5. (a) Affects Safety Basis: ☐ Yes ☒ No	(b) Affects SNF/HLW: ☐ Yes ☒ No

6. Summary:

Purpose

The purpose of this EDF is to further clarify and provide an evaluation of the feasibility to perform Alterative 4 for the Engineering Evaluation/Cost Analysis for the EBR-II Final End State.

This EDF was prepared to support *the Engineering Evaluation/Cost Analysis (EE/CA) for the EBR-II Final End State* (DOE/ID-11398), January 2010. Specifically, this EDF provides additional detail for the technical feasibility for removal, transport and disposal of the EBR-II reactor vessel and is the basis for the technical feasibility discussion for the EE/CA Alternative 4. Alternative 4 includes demolition of the EBR-II reactor building and removal and disposal of the EBR-II reactor vessel. See the EE/CA for further background information on the EBR-II reactor.

This EDF explores two options for reactor disposal. The first option is to lift and remove the reactor vessel itself from within the primary tank for disposal. The second option is to retain the reactor vessel inside the primary tank, break the upper T-1 structure free from the surrounding monolith and lift the entire assembly for disposal.

Conclusion

The technical feasibility of the two options for disposal of the EBR-II reactor have been evaluated. Both options pose challenges that are unique to the INEL. The first option explores the feasibility of removing the reactor vessel exclusive of the primary tank. This option would require disassembling the primary components in the reverse sequence as assembled to remove the reactor vessel. This involves removing components, cutting piping, disconnecting bolts, and cutting welds from around the base of the reactor vessel, while remotely working within the primary tank. Because of the high dose rates and the limited penetrations in the primary lid and the T-1 structure this option poses many technical challenges that may not be feasible. Additionally, since the reactor vessel components were assembled inside the inner primary tank, the reactor vessel would need to be rigged and lifted out of the T-1 structure rotating plug opening, which is dimensionally infeasible.

The second option explores the feasibility of removing the reactor vessel inclusive of the primary tank. This option would break the T-1 structure radial beams out of the bio-shield, and lift the entire vessel package including the T-1 structure radial arms, the upper bio-shield concrete, the primary lid and shielding, the inner and outer primary tank and all components within the primary tank. The total vessel package would weigh approximately 1500 tons. Due to the configuration of the vessel this option is feasible; however, several technical challenges would need to be overcome to accomplish this task. The transportation from MFC to the ICDF would be the main difficulty due to the weight of the reactor package and the size of the transport trailer.

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7. Signatures: (See instructions for significance of signatures. Add or delete signatories as needed.)

Name (typed or printed) / Signature and Date	Signatory Role	Organization / Discipline
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N/A	Reviewer	* Quality Assurance (only if 5(b) is "Yes")
N/A	Reviewer	* Nuclear Safety (only if 5(a) is "Yes")
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8. Does document contain sensitive unclassified information? ☐ Yes ☒ No

If Yes, what category:

9. Will document be externally distributed? ☐ Yes ☒ No

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10. Registered Professional Engineer's Stamp (if required)	☒ N/A
Registered Professional Engineer Stamp	This Engineering Design File was prepared under the direction of the Registered Professional Engineer as indicated by the stamp and signature provided on this page. The Professional Engineer is registered in the State of Idaho to practice _____ Engineering.

* Not required for commercial level calculations

1. Reactor Vessel Removal Exclusive of the Primary Coolant Tank

In order to understand the complexities of Reactor Vessel Removal, it is beneficial to understand the installation of the Primary Tank and Reactor Components.

The Primary Tank inner and outer vessels were constructed on the Reactor building operating floor, inside the containment building. The thank bottoms were constructed first (as shown in figure 4.7-9 below); both tank side walls were erected concurrently.

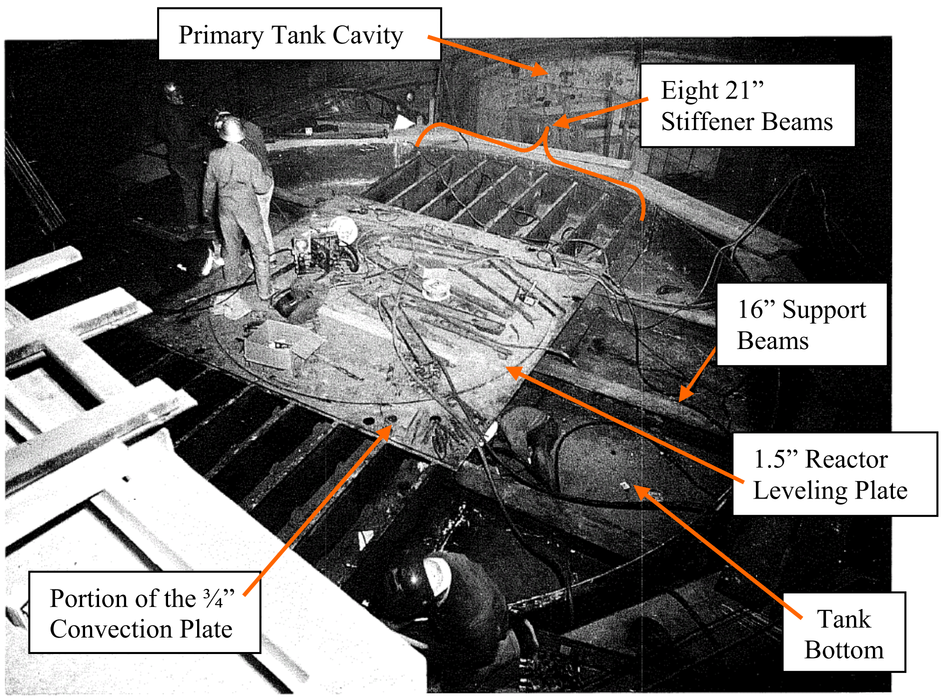
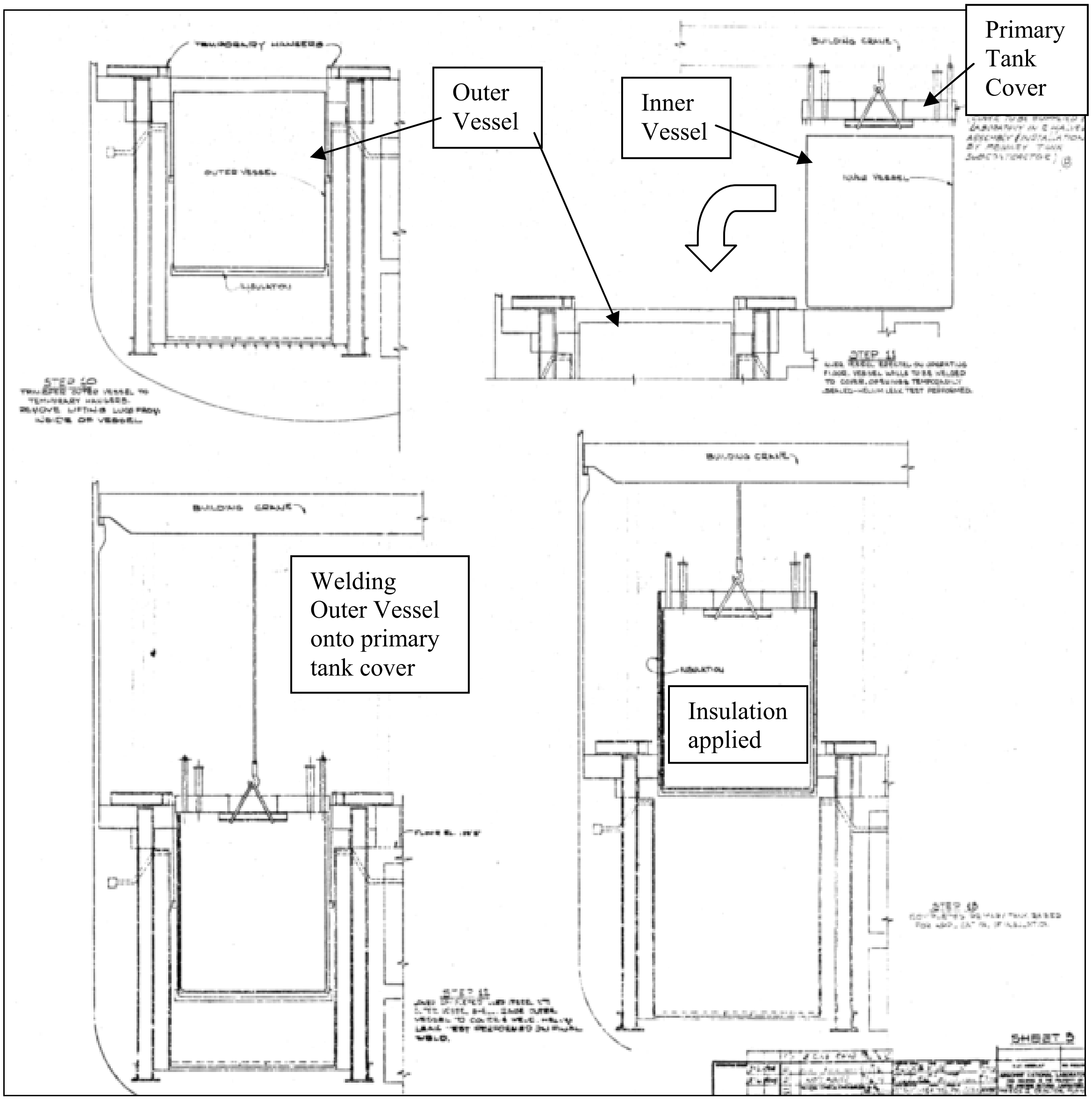


Figure 4.7-9 Inner Vessel Bottom Assembly

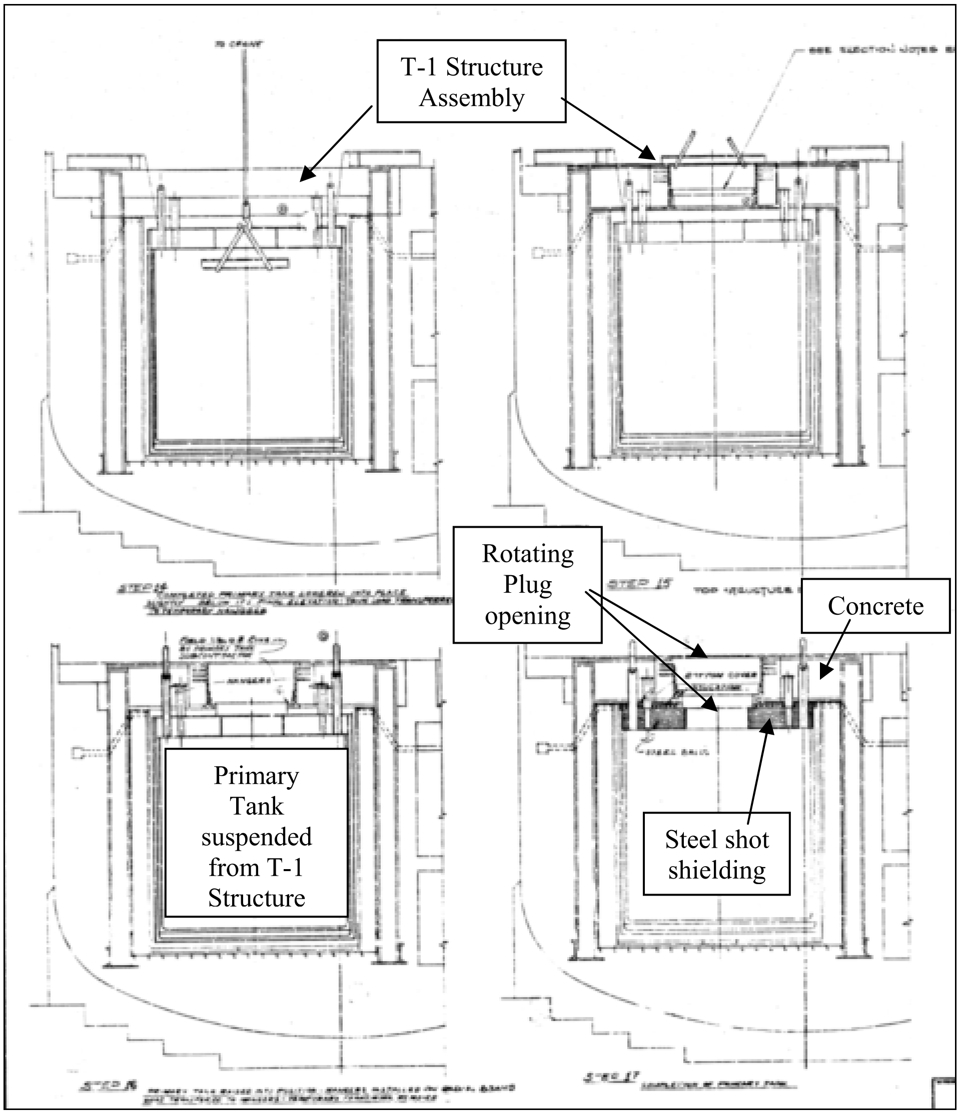
4.7-17

After the vessels were completed, the outer vessel was lowered into the primary cavity and then the inner tank was lowered into the outer tank. The two halves of the Reactor Cover were joined inside the containment building then welded onto the inner tank, then to the outer tank. The primary vessel was raised to install two layers of insulation on the outside of the outer vessel. The tank was again lowered into the cavity. The radial arms and center ring of the T-1 structure were installed and the primary tank was raised and connected to and suspended from the T-1 Structure as shown in the following drawing sequence.[1]

[1] See construction sequence drawings EB-1-25252-E, EB-1-25252-F, EB-1-25254-E. EB-1-25255-E, EB-1-25247-E, EB-1-25229-E, EB-1-25267-D, EB-1-25268-D, EB-1-25179-F, EB-1-25181-F, EB-1-25208-F,



Primary Tank Cover
Outer Vessel
Inner Vessel
Welding Outer Vessel onto primary tank cover
Insulation applied
TEMPORARY HANGERS
OUTER VESSEL
INSULATION
BUILDING CRANE
INNER VESSEL
STEP 10
STEP 11
STEP 12
STEP 13
SHEET 5



This is also shown in the following photographic sequence taken during construction:

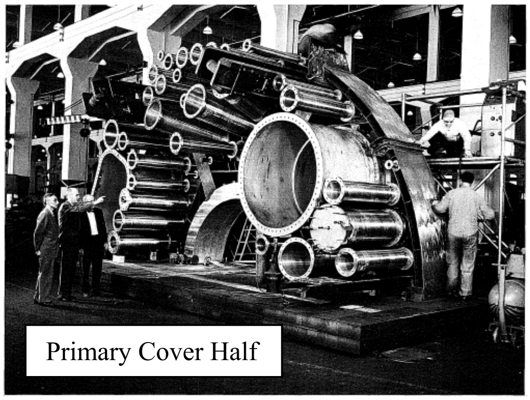


Figure 4.7-3 Helium Leak-Testing the Welds in a Completed Cover Half

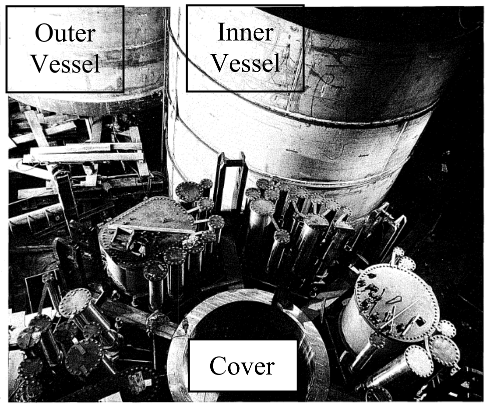


Figure 4.7-10 Primary Tank Cover Half Assembly

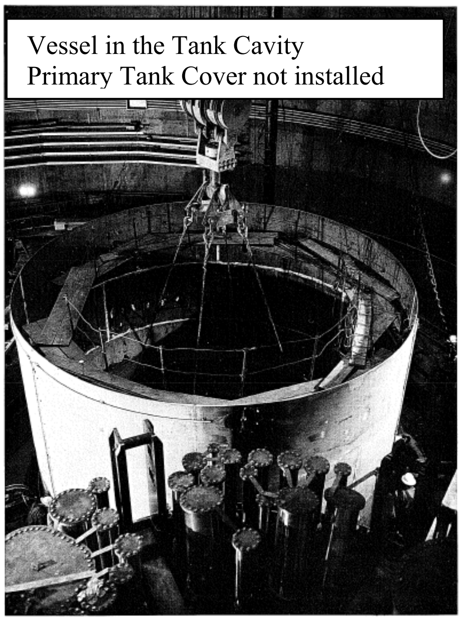


Figure 4.7-11 Inner and Outer Vessel Partially Lowered into Cavity

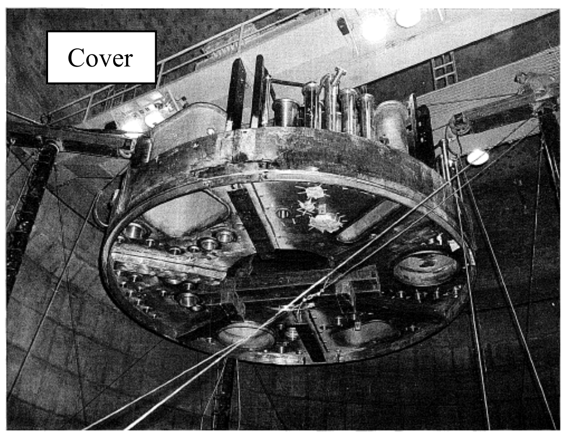


Figure 4.7-12 Primary Tank Cover Ready for Installation

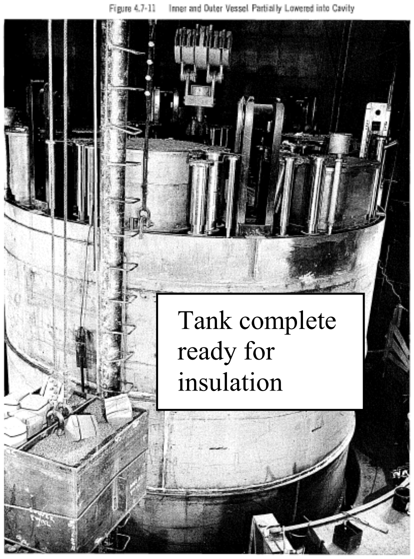


Figure 4.7-13 Completed Primary Tank and Cover Ready for Side Wall Insulation

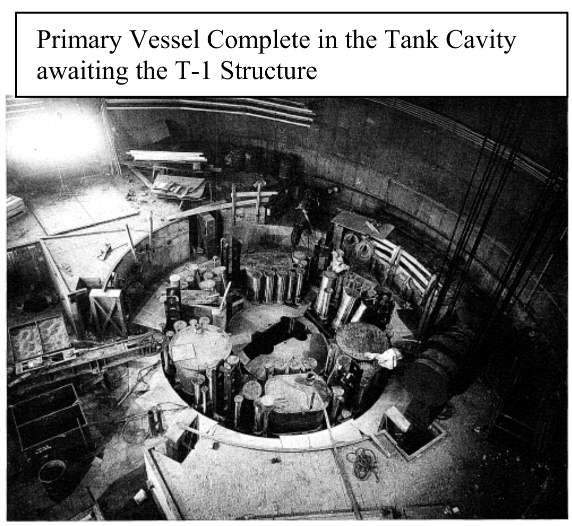


Figure 4.7-14 Primary Tank Positioned for Central Ring and Radial Beams

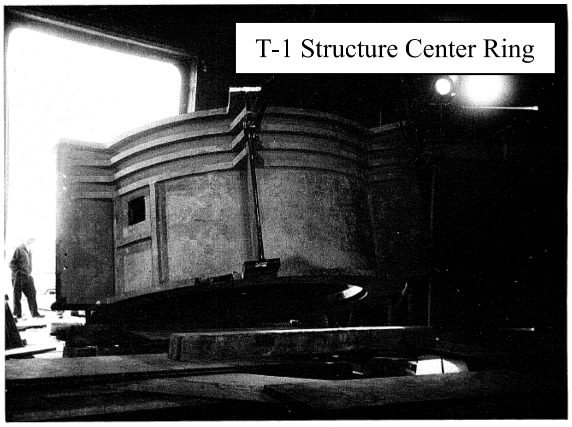


Figure 4.7-15 Moving Central Ring and Radial Beams into Reactor Building

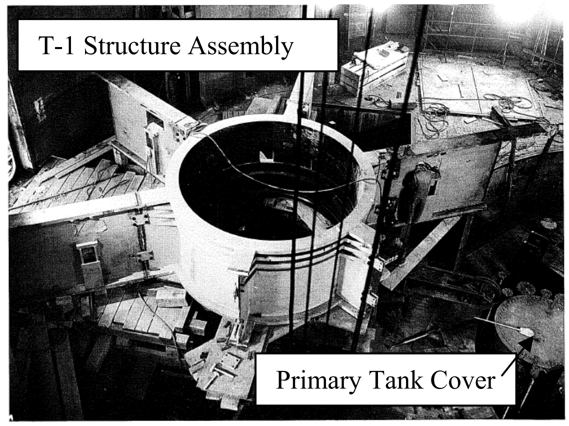


Figure 4.7-16 Partially Assembled Central Ring and Radial Beams

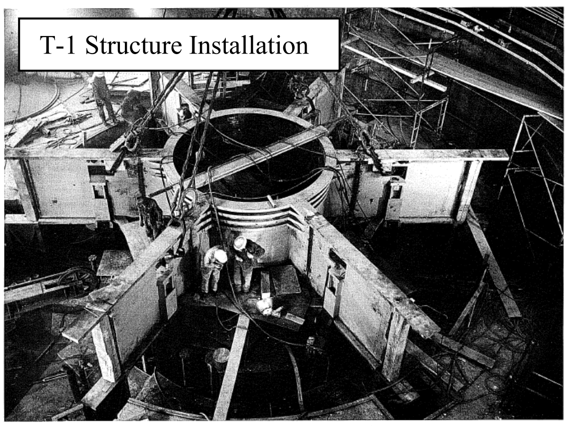


Figure 4.7-17 Welding Radial Beam Solice Joints

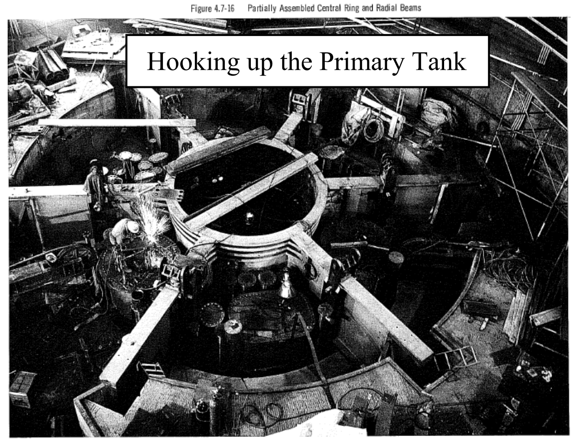


Figure 4.7-18 Leveling Support Structure on the Columns

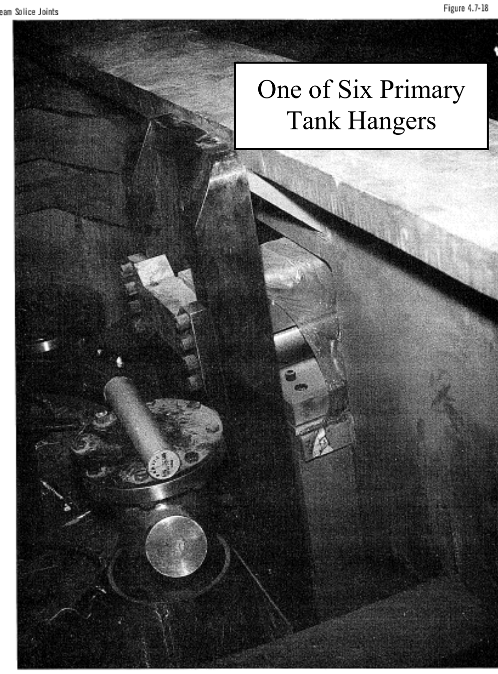
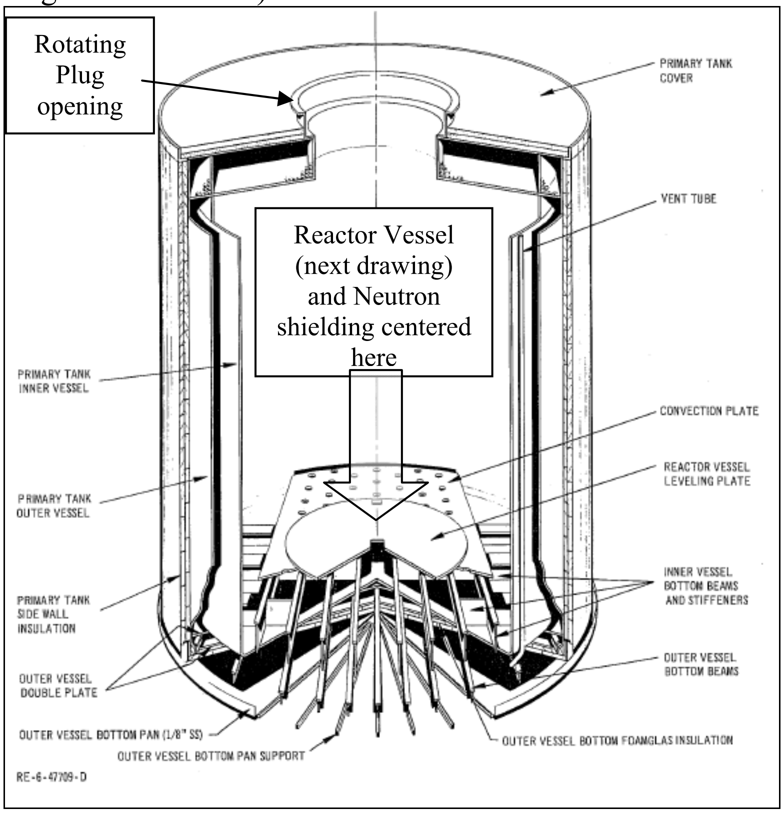


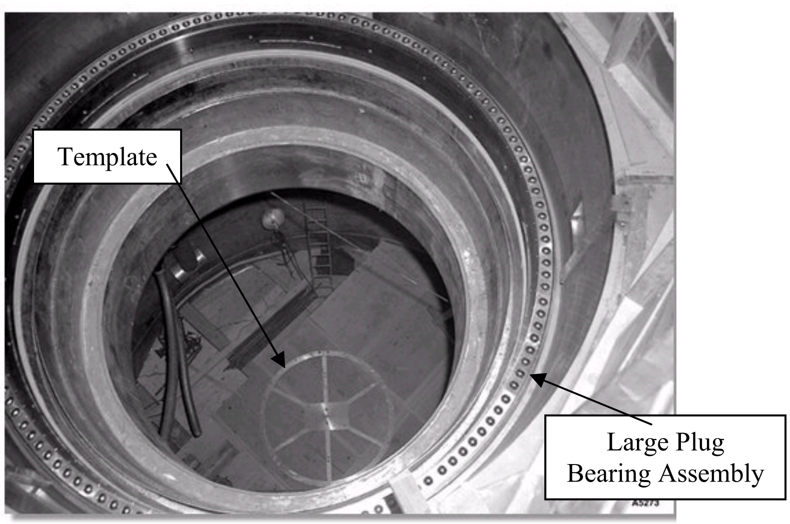
Figure 4.7-19 Primary Tank Hangers and Roller Support System

4.7-2

With the primary tank completed and suspended from the T-1 Structure, the Reactor Vessel was assembled on the Reactor Leveling Plate and the Convection Plate, shown below (see also figure 4.7-9 above).



The bottom of the primary tank is shown, through the Large Rotating Plug opening, without the Reactor Vessel in place. The Convection plate is also shown covered with some protective material.



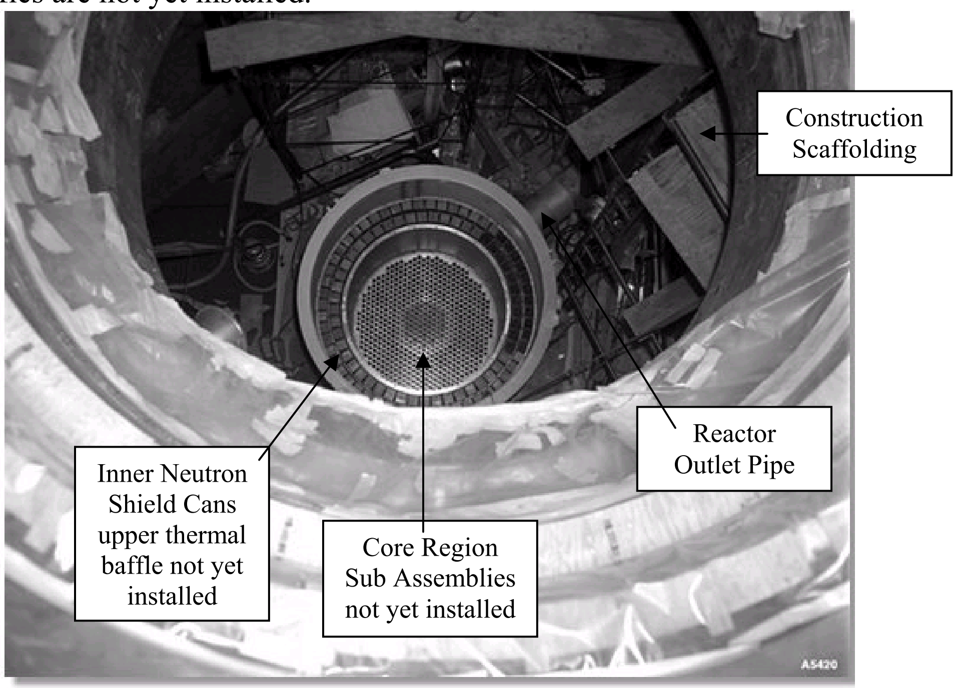
A5273.jpg

http://nike/archive/5000/A5000/imagepages/image1.html

A "wagon-wheel" template (drawing RE-1-32984-D) was used to drill the Reactor Leveling Plate and match up with the Reactor Vessel Grid Flange.

The large rotating plug opening had a stair-step opening (upper diameter 11'10", lower diameter 9'0") provided for shielding, the knife seal ledge, and the bearing assembly for the Large Rotating Plug (see photo A5273.jpg above).

With the holes in the Reactor Leveling Plate, the Reactor Vessel was assembled in the tank. The inner neutron shield cans are in place but the thermal baffles above them are not yet installed. The inner neutron shielding cans are clearly visible but the upper thermal baffles are not yet installed.

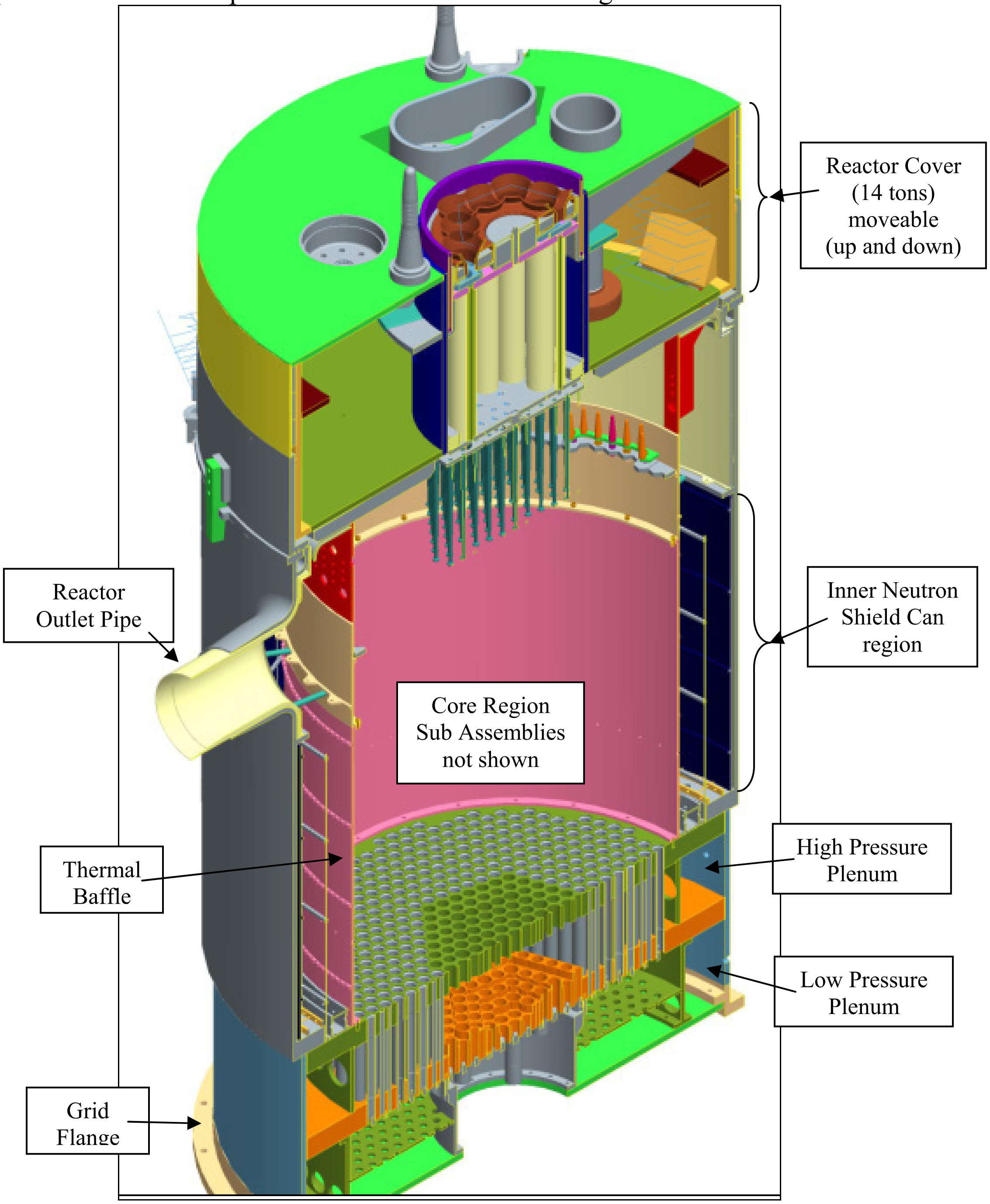


A5420.jpg
http://nike/archive/5000/A5000/imagepages/image8.html

The outer neutron shielding, including the upper neutron shield where the Reactor Cover Lock (K-nozzles) attaches, is also not yet installed.[2] The Reactor Cover is also not yet installed.

[2] Other construction photos of interest: http://nike/
http://nike/archive/5000/A5000/imagepages/image4.html
http://nike/archive/5000/B5000/imagepages/image3.html
http://nike/archive/5000/B5000/imagepages/image4.html

Like the primary tank, the EBR-II Reactor Vessel was assembled from several different components and sub components as shown in the following model.



NOTE: Inner neutron shield cans, upper thermal baffle and Reactor Subassemblies are not shown in this drawing.
The outer neutron shield cans surrounded the Reactor Vessel.

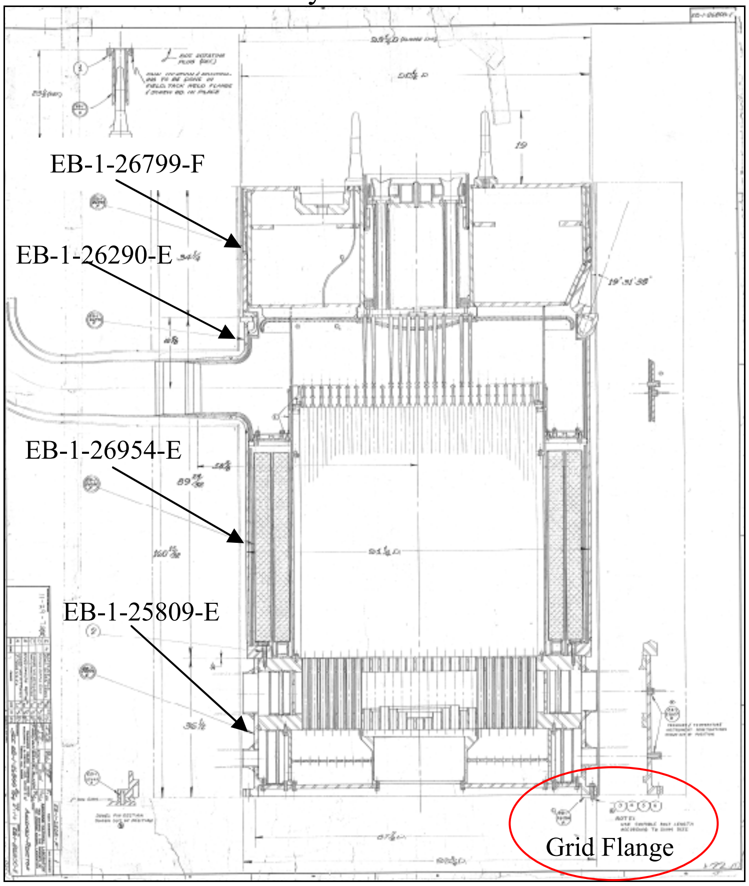
The components were assembled according to the following table (see drawing EB-1-26800-E Assembly- Reactor):

EB-1-26800-E	Assembly - Reactor		
	Component Drawing # and Title		
		Sub component Drawing # and Title	
	EB-1-25809-E Assembly Reactor Vessel Grid		
		EB-1-25812-F	Sub Assembly Reactor Vessel Grid
		EB-1-25810-D	Flow Distribution Plenum
		EB-1-25452-E	Reactor Vessel Lower Plenum Wall
		EB-1-25811-D	Bottom Plate - Reactor Vessel Lower Plenum
	EB-1-26954-E Reactor Vessel Internals		
		EB-1-26249-C	Thermal Baffle Lower Vessel Shell
		EB-1-26250-A	Lower Thermal Baffle
		EB-1-38566-B	Shield Can Empty
		EB-1-25420-D	Neutron Shielding Full Can Assy
		EB-1-26244-D	Inner Shell - Lower
	EB-1-26290-E Reactor Vessel Sub Assembly		
		EB-1-26427-B	Reactor Plenum Outlet Nozzle
		EB-1-26111-E	Reactor Vessel Shell
	EB-1-26799-F Cover - Reactor Vessel		
		Numerous sub components	

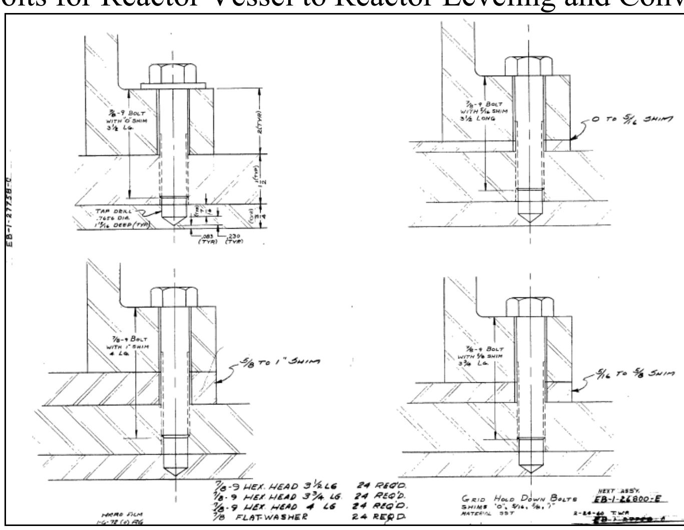
The sub components were bolted and welded together to form the finished reactor. The reactor vessel was centered, plumbed, leveled, shimmed[3], bolted[4] and then welded[5] to the Reactor Leveling Plate (EB-1-25181-F) which is welded onto the Convection Plate and the bottom of the primary tank. The reactor internals, including the thermal baffles and two concentric rings of inner neutron shield cans were added, bolted and welded in place. Un-fueled stainless steel sub assemblies (in place of fueled sub assemblies), safety rods (connected to the Safety Rod Support Beam[6] installed below the convection plate), and control rods[7] were also installed.

[3] EB-1-27758-C
[4] EB-1-27758-C
[5] EB-1-25809-E (indirect reference)
[6] EB-1-25273-D EB-1-25181, EB-1-25400-F, EB-25394-C
[7] Example EB-1-25961-E, Note: example provided may not be a non-fueled sub assembly.

EB-1-26800-E Reactor Vessel Assembly



Shims and Bolts for Reactor Vessel to Reactor Leveling and Convection Plates.



Drawing EB-1-27758-C

The bolts were tack welded in two locations. Welding may also have occurred.

With the Reactor Vessel in place, two 12-inch High Pressure and two 4-inch Low Pressure inlet pipes were welded to the high and low pressure plenum inlet nozzles. The 14-inch reactor outlet pipe with 18-inch thermal shroud was welded to the reactor outlet nozzle (see drawings EB-1-25231-F and EB-1-26050-F). Reactor Instrumentation, thermocouples and pressure transmitters, were also added to the reactor vessel (see drawings EB-1-27627-D, EB-1-27312-E, RE-2-34599-D, EB-1-29015-E, EB-1-29017-E, EB-1-29018-E, RE-2-34655, EB-1-29019-E, EB-1-29021-E, and EB-1-29022-E). This work was done with personnel inside the primary tank below the Reactor Cover.

The EBR-II Reactor Vessel and all primary components were assembled and installed inside the primary vessel cavity. Personnel entered through the openings in the Reactor cover to do the assembly.

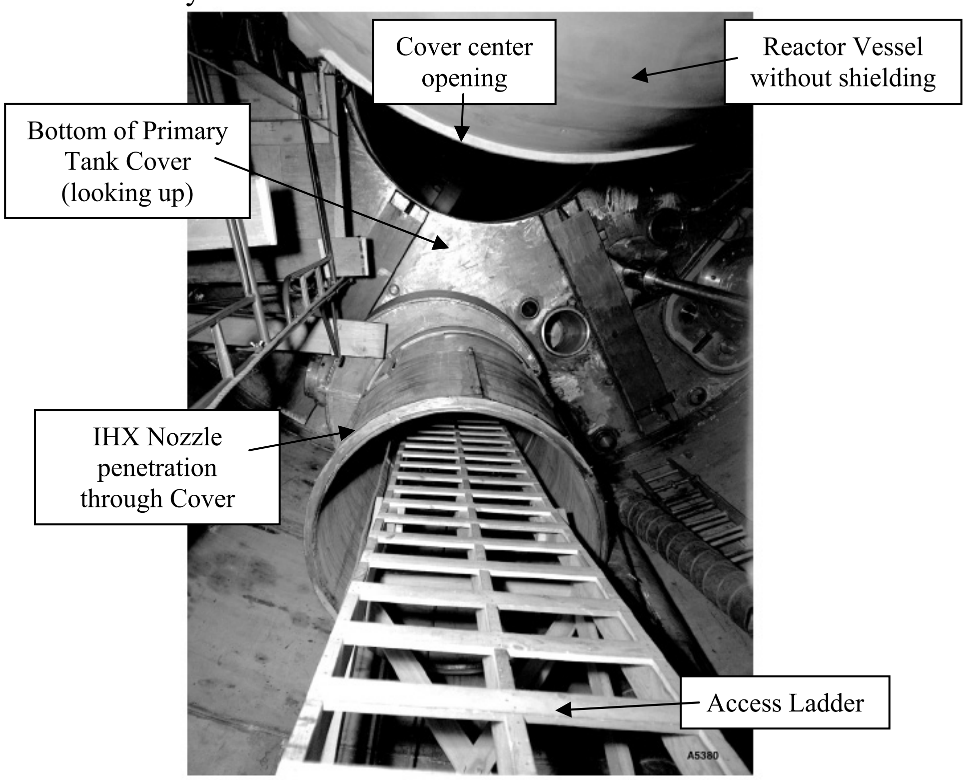
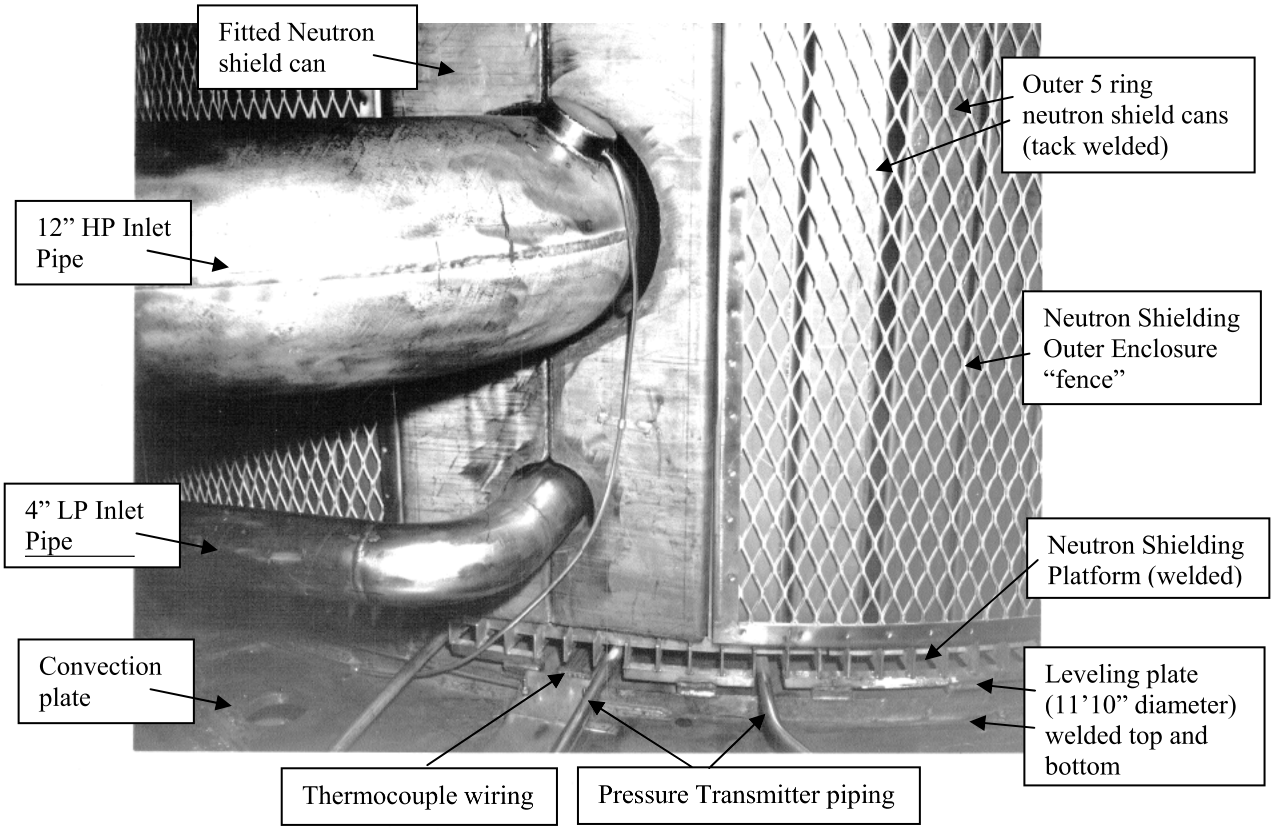


FIGURE 2-16. OPEN NOZZLE FOR THE IHX (LOOKING UP).

Surrounding the Reactor Vessel Grid Flange, the outer Neutron Shield Inner Enclosure (EB-1-25418-D) and the (outer) Neutron Shielding Platform (EB-1-27235-C) were field welded in place to the Reactor Leveling Plate. A 20" Schedule 10 pipe was also welded around the reactor vessel outlet pipe to provide shielding support (EB-1-25418-D). Five concentric rings of outer neutron shielding cans (EB-1-25420-D) surrounded the reactor vessel (EB-1-25416-F)[8] in three tiers. ¼ -inch filler strips were tack welded in place to fill in left over spaces between cans as required.[9] Expanded metal supports were welded

[8] See also EB-1-27306-D and EB-1-25421-D
[9] Note 3 EB-1-25416-F)

in between each tier (EB-1-25421-D) which is welded to the Neutron Shielding Outer Enclosure or "fence" (EB-1-15419-E). The fence was constructed of 30 panels (ten per tier) and was tack welded to the neutron shielding cans (See photo ANL-ID-103-D5260) and to the Neutron Shielding Platform which was welded to the Convection Plate (ANL-ID-103-D5219).



ANL-ID-103-D5219 PRIMARY TANK. REACTOR INLET PIPING.

The neutron shielding was engineered to fit around the inlet and outlet pipes, the J-nozzle nuclear instruments and the three reactor vessel cover locks (K-nozzle).[10]

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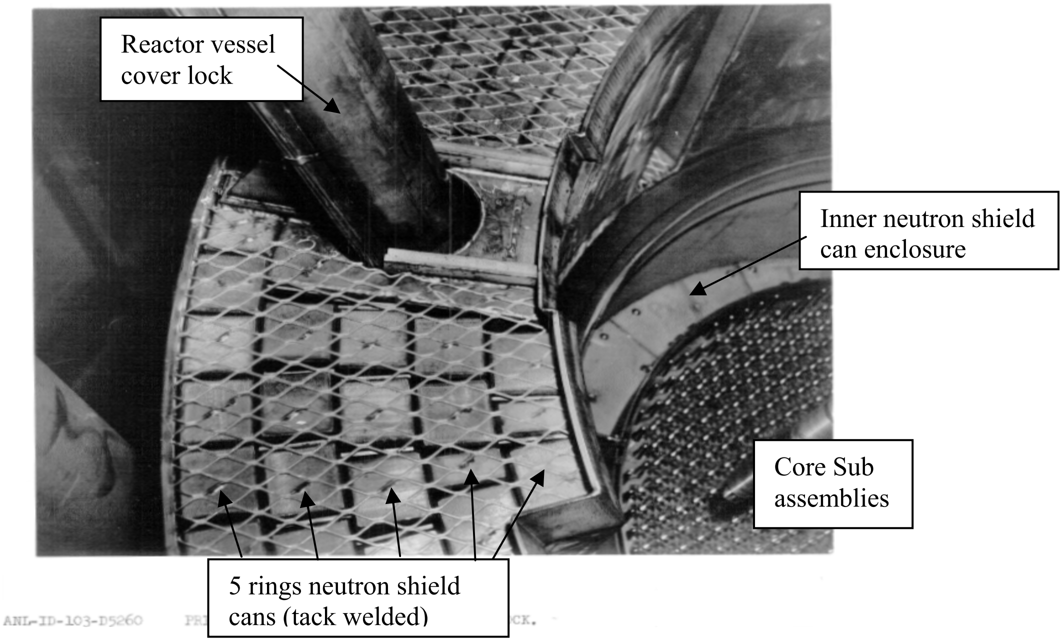
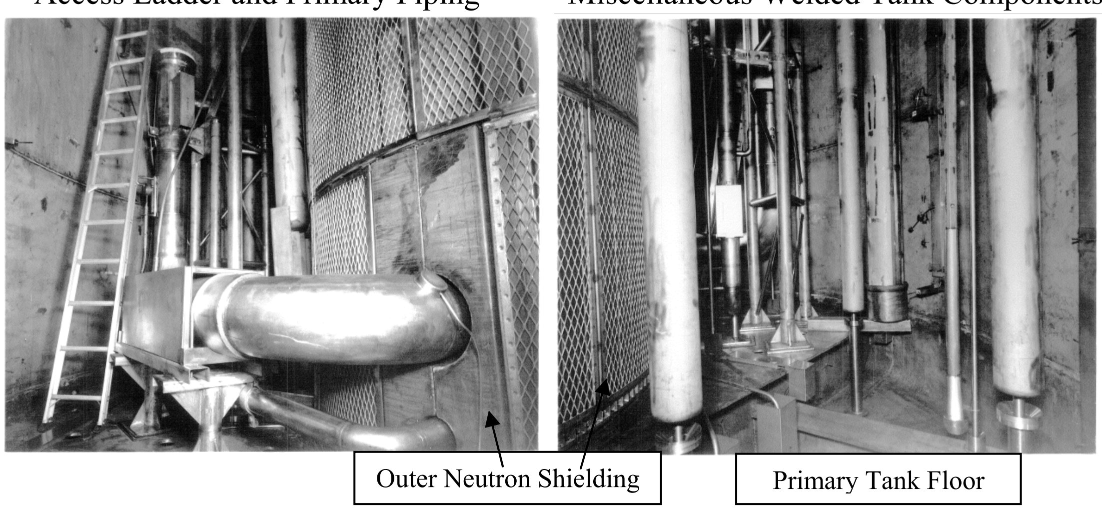
[10] See drawings EB-1-27235-C, EB-1-27247-D, EB-1-27248, EB-1-27300-D, EB-1-27301, EB-1-27302-D, EB-1-27303-D, EB-1-27304-D, EB-1-27305-D, EB-27306-D, EB-1-27307-D, Eb-1-27308, EB-27309, EB-1-27310-D, EB-1-27311-D, EB-1-27313-B



The J-Thimbles EB-1-27303-D, EB-25418-D, are inserted into the outer neutron shielding. The lower portion of the guide tube for the Reactor Vessel Cover Locking Mechanism is welded to the radial neutron shield which surrounds the Reactor Vessel[11] (at the Reactor Vessel Cover.

Access Ladder and Primary Piping | Miscellaneous Welded Tank Components



Specific Steps for Reactor Vessel Removal Exclusive of the Primary Tank

[11] Design Manual Section 5.3 page 5.3-1 through 5.3-4, EB-1-26149-C

Limitations
The Center Ring in the T-1 Structure has a maximum inside diameter of 11' 10" (EB-1-25290-F).[12] Several stair-step support structures reduce this maximum diameter to support the weight and provide shielding for the large rotating plug, including the freeze seal[13] down to the opening in the Reactor Cover. The Reactor Cover center opening has an inside diameter of 9' 0" (EB-1-25179-F, EB-1-25290-F).[14]

The Reactor Vessel diameter at the Grid Flange is 93-½ inches (7 feet 9.5 inches). If the Reactor Vessel could be removed from the Leveling Plate, the bare reactor vessel would fit through the opening of the Primary Tank Cover (Large Rotating Plug opening if the Large Plug was removed, and with reactor vessel appendages removed).

The Outlet Plenum extends between twelve[15] and 19.75[16] inches beyond that. Using the shorter distance, the total width of the vessel is 8.7 feet which also fit though the reactor cover. However, the longer distance, totaling 9.4 feet, would preclude removal through this opening.

The Outer Neutron Shielding has an outer radius of 66.96 inches (ANL-6614 EBR-II Shield Design Manual pg 21) or a diameter of 133.92 inches (11.16 feet) [11' 9-½" per drawing RE-6-49240-F]. If the assembly, Reactor Vessel and Neutron shielding could be cut out from the primary tank (at the convection plate) as a unit, this assembly could not be removed through the nine foot opening in the primary tank cover.

Steps for removing the reactor vessel from the primary tank (separate from removal of the primary tank).This is essentially, the reverse sequence of Reactor assembly or disassembly of the reactor vessel required to be done remotely without personnel in the primary tank.

1. Removal of three Reactor Cover Locks: K1, K2, and K3
    a. Were not removed at any time before.
    b. Maybe able to remove the locking mechanism from the Operation Floor, but incur associated radiation levels of removed components from 30 years of operations.
    c. Lower sheath supports are welded to the outer neutron shield inner vessel, which would have to be cut out prior to vessel removal.
2. Removal of four nuclear instruments and thimbles: J1, J2, J3, and J4, to provide access to the neutron shields and vessel
    a. Three Nuclear Instruments are still installed. All four thimbles are still installed.

[12] Design Manual Section
[13] See Design Manual Section 5.5, Figure 5.5-2 (page 5.5-4) and Figure 5.5-17(page 5.5-30)
[14] Design Manual Section 4.6.1.2, page 4.6-2.
[15] EB-1-26800-F Assembly - Reactor
[16] EB-1-26427-B Reactor Plenum Outlet Nozzle

   b. Thimbles have not been removed before. They may or may not be able to be removed from the RX floor (i.e. the thimbles may be attached to the RX vessel (see drawing RE-6-49025 Fig A.2.11). There may be other interferences in the way of removal internal to the primary tank.
   c. Associated radiation levels of removed components from 30 years of operations.
3. Removal of three small instrument and thimbles: O1, O3 and O4, to provide access to the neutron shield cans (The O2 thimble has already been removed).
   a. Able to be removed from the RX floor.
   b. Associated radiation levels of removed components from 30 years of operations.
4. Removing the Small (45 tons) and Large (58 tons) Rotating Plugs.
   a. Lowering the RX cover (weight 14 tons) or removing it with the Large/Small rotating plug
   b. Result - high radiation levels in the main floor of the reactor building
   c. Exposing a contaminated primary vessel
5. Removal of the outer neutron shield cans (3 tiers, 5 concentric rings each).
   a. Removal of the “fence.” Removal of the fence would require significant amount of engineering for remote removal.
   b. Removing 5 rings of neutron shield cans will result in radiation levels outside the reactor vessel to increase from 10-40 R/Hr to over 200 R/hr.
   c. Remote removal of the fence and the outer neutron shielding must be done remotely.
6. Cutting the primary coolant inlet and outlet piping at the Reactor Vessel consisting of
   a. Two 12” High Pressure inlet headers,
   b. Two 4” Low Pressure inlet headers,
   c. One 14” Outlet Header with 18” shroud
7. Removal of all pressure and thermocouple instruments and associated piping from the RX vessel.
   a. Is there anything else in the way of the primary tank?
8. Unbolting/cutting the RX vessel from the convection plate and/or leveling plate (RE-6-47709, Fig 4.6-1).
   a. These are located at the bottom of the Reactor Vessel (about 2 feet off the bottom of the primary vessel) – see photo (fig. 4.7-9 pg. 4.7-17)
   b. Cutting might be done remotely, with significant engineering.
9. Lifting through the 9-foot ID Large Rotating plug/Reactor Cover opening
   a. Provide suitable lifting mechanism.
   b. Significant shielding on the RX floor.

Alternate:
Removing the RX vessel and neutron shielding through an enlarged opening in the Primary tank Cover: Steps 1 – 4 from above would still be required (see Fig 4.7-15 – 18 pgs 4.7-23 – 26)

NOTE: May still not fit – The leveling plate is 11'10" in diameter, which is the same size opening as the T-1 structure.

1. Engineering method to enlarge the primary tank cover opening to the ID of the T-1 structure center ring:
   a. This would significantly alter the structural integrity of the primary tank cover used to support all other primary tank components.
   b. Steel Shot would need to be removed from the tank cover used as shielding.
   c. Never been done before.
   d. Cutting through concrete and steel shot shielding of the primary tank cover to expose larger opening that the reactor vessel and the neutron shielding may fit through.
2. Cutting the primary coolant inlet and outlet piping at the neutron shielding consisting of
   c. Two 12" High Pressure inlet headers,
   d. Two 4" Low Pressure inlet headers,
   e. One 14" Outlet Header with 18" shroud
3. Removal of all pressure and thermocouple instruments and associated piping from the RX vessel.
   a. Is there anything else in the way of the primary tank including the neutron shielding?
4. Cutting the primary support plate around the neutron shielding and RX vessel
   a. Cutting method to be determined.
   b. 8 beams would have to be cut
   c. Be aware of the stainless steel plate shielding below the Reactor Vessel at the bottom of the primary tank (EB-1-25181-F)
5. Lifting RX vessel and shielding through the new larger opening
   a. Providing a support mechanism to lift the RX vessel and Shielding.
   b. Less shielding on the RX floor compared with 9a above, but still significant shielding required
   c. Main building crane may not be able to lift.

2. Reactor Vessel Removal Inclusive of the Primary Coolant Tank

Terminology:

For purposes of section 2 the term "primary vessel package" consists of the radial T-1 structure, the inner portion of the upper bio-shield, the rotating plugs, the primary tank cover, all components attached to the cover, and all components inside the primary tank outer vessel, i.e., the inner primary tank, all piping within the tank, the heat exchanger components, and the reactor core (See Figure 1). The primary vessel package also includes the additional weight of 16 ft of low density grout used for shielding the reactor core within the primary tank. The dimensions of this package will be approximately 38 ½ ft tall, 40 ½ ft diameter at the upper T-1 structure, and 27 ft diameter at the outer primary tank body (See Figure 2).

Steps Required to Lift and Transport the Primary Vessel Package:

1. Grout the vessel – The vessel will need to be filled with low density grout (approximately 70 to 80 pcf) to reduce the radiation exposure during lifting operations. The height of the grout within the primary tank will be approximately 16 ft to encompass the reactor core. The total weight of the grout at this depth equates to approximately 679,600 lbs.

2. Widen the Reactor Building Shell Door to Provide Equipment Access – In order to drive heavy equipment into the EBR-II building that will aid in demolition of the reactor bio-shield the east shell access door will need to be widened. The door is currently approximately 8 ft wide. This will require cutting through the 1 inch steel plate of the building shell and demolishing the 1 ft thick concrete on the inside of the steel plate. An evaluation will be required to ensure the structural integrity of the remaining concrete and steel is adequate when the larger section is removed.

3. Move Heavy Equipment into EBR II to Assist in Demolition – As a minimum the Caterpillar 345B excavator will be required to traverse the floor of EBR. An analysis or evaluation of the floor will be required to insure the structural integrity of the floor during demolition. The 345B Excavator weighs approximately 112,000 lbs. Additional modification may be necessary to strengthen the floor or distribute the loading.

4. Break Out the Upper Bio-Shield Outer Section – The upper bio-shield consists of a 3 ft 3 inch thick layer of high density concrete (approximately 280 pcf, See Figure 3). The concrete is impregnated with 1 inch diameter steel balls for shielding. There are two main sections of the upper bio-shield, which are referred to here as the outer and the inner sections. The distinguishing factor between the two sections is the

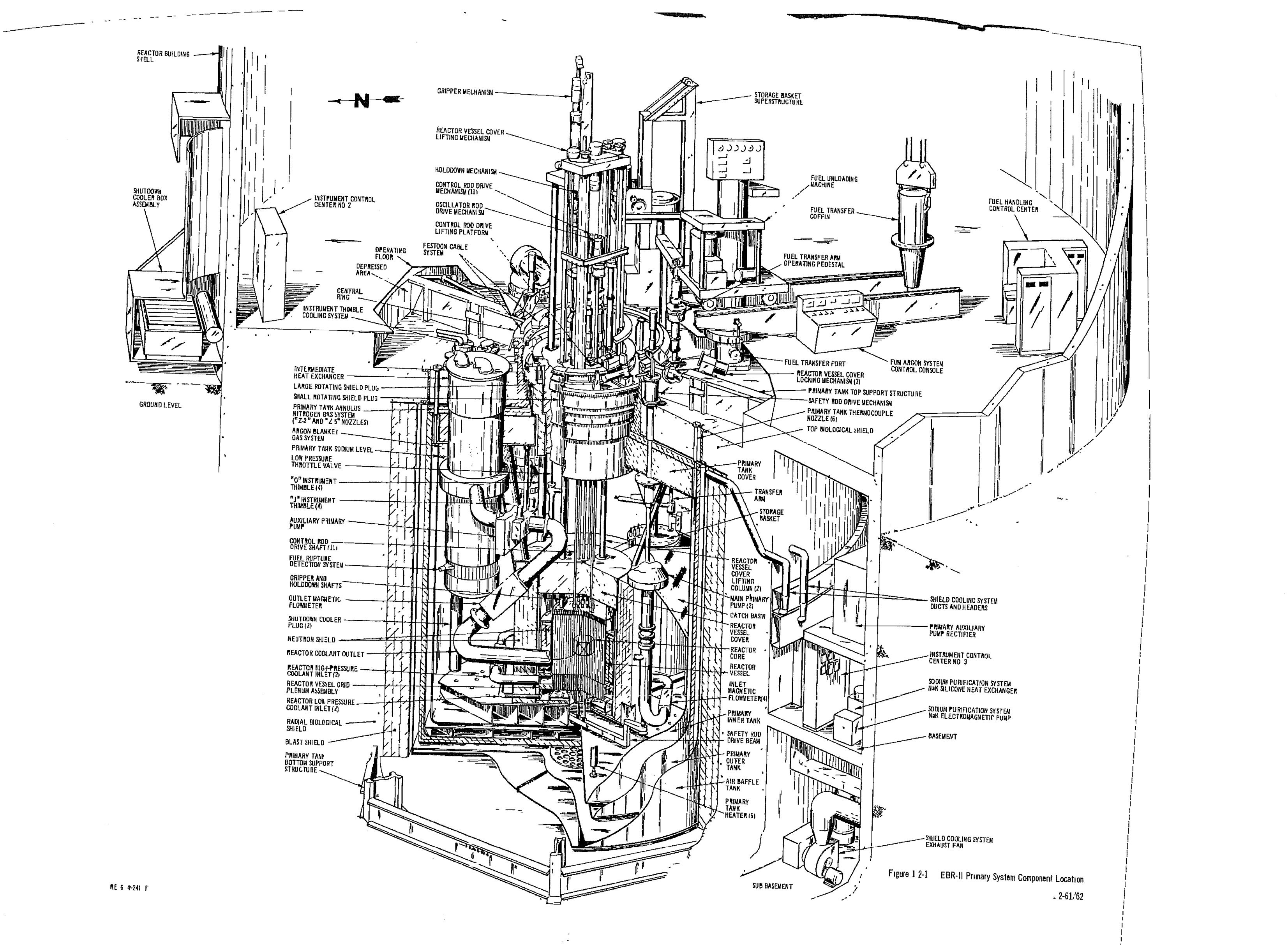


Figure 1 2-1 EBR-II Primary System Component Location

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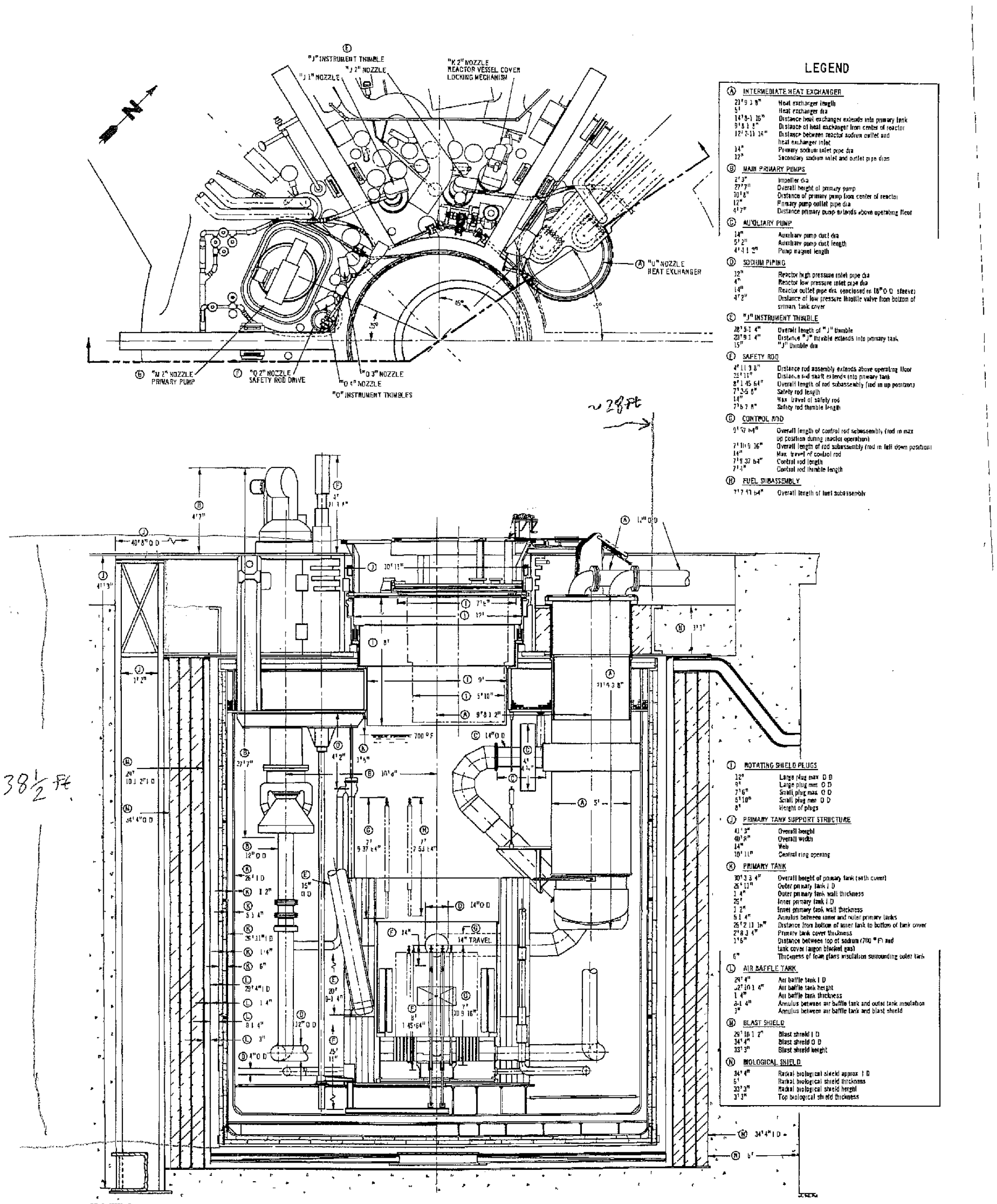

Figure 1 2-2 Primary System Dimensional Data (Sheet 2 of 2)

1 2-65/66

~ 38.5 ft Tall w/ Rotating Plug & T-1 structure

~12.5 ft too high for ICDF

large curved channel beams, which are installed between the radial T-1 structural beams. A 3 ft wide section of the bio-shield located on the outer portion of the curved channel beam in-between the T-1 main beams will need to be broken out around the perimeter of the T-1 structure to gain access to the 1 inch thick steel form plate that was installed on the bottom of the T-1 structure (See Figure 4). The 1 inch thick form plate supports the upper bio-shield. With the exception of any lower piping connections, by breaking out this portion of concrete and cutting the radial T-1 beams as discussed in step 5, the primary vessel package will be free. The primary tank is currently supported and suspended by the T-1 structure via six hangers (See Figure 5). The spread of contamination during the breakout of the concrete will need to be controlled during this evolution.

5. Cut the Radial Beams of the T-1 Structure at the Interface of the Supporting Columns – The radial I-beams that compose the T-1 structure support the entire primary containment tank, the tank cover, and the upper bio-shield. These I-beams will need to be cut at the interface of the supporting columns (that reside within the biological shield, See Figures 3, 4, and 5). Though the T-1 structure was initially installed in separate pieces it was bolted and field welded to the supporting columns. The T-1 beams are 6 ft 6 inch deep with 14 inch wide flanges. The supporting columns are 14 inch deep I-beams with 14 inch wide flanges. The T-1 beams were welded to the column beams with a full penetration weld. This weld will need to be cut to release the entire primary vessel package. The upper flange of the T-1 beams would be left intact during this evolution so that the weight of the structure would be supported during the cutting. Then the eight large bolts that fasten the top flange of the T-1 beams to the columns can be removed. Contamination control during plasma cutting would be required during this evolution.

6. Jack the Primary Vessel Package – After breaking away the bio-shield and freeing the T-1 structure it will be necessary to jack the vessel package to ensure there will be no hang-ups during the lift. A method for jacking (and jacking fixtures if necessary) will need to be designed, and analyzed. This could be a difficult operation due to the lack of access to the bottom of the vessel.

7. Protect the T-1 Structure to Prepare for the Building Shell Demolition – The building shell consists of two main configurations. The lower cylindrical shape up to an elevation of 176 ft is constructed from 1 inch thick steel plate with 1 foot thick blown in concrete adhered to the inside face of the steel. The upper dome section is constructed from ½ inch thick steel plate with 4 inches of blown in shot Crete adhered to the inside face of the steel. When the structure is demolished there will be tons of rubble falling from the upper dome structure that could potentially damage the T-1 structure. Since the T-1 structure will be used to lift the Primary Reactor Vessel it would need to be protected during demolition. A method of protecting the T-1 structure would need to be engineered and designed.

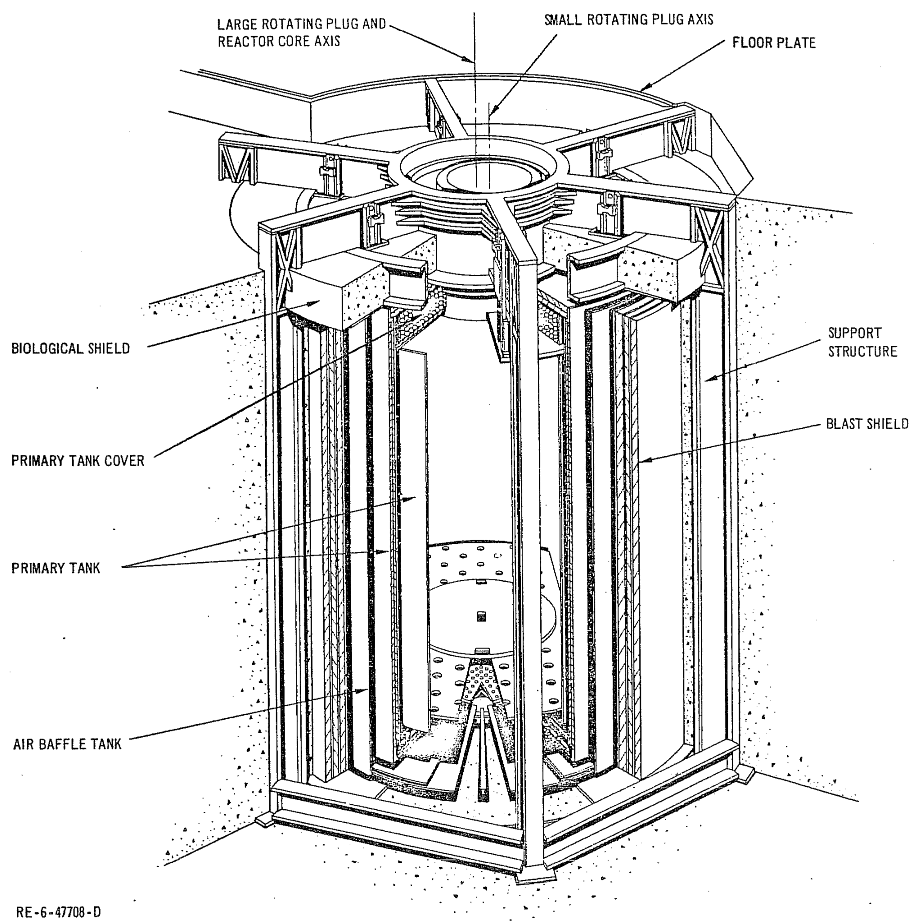

Figure 4.1-1 Primary Tank Assembly

4.1-3

FIGURE 3

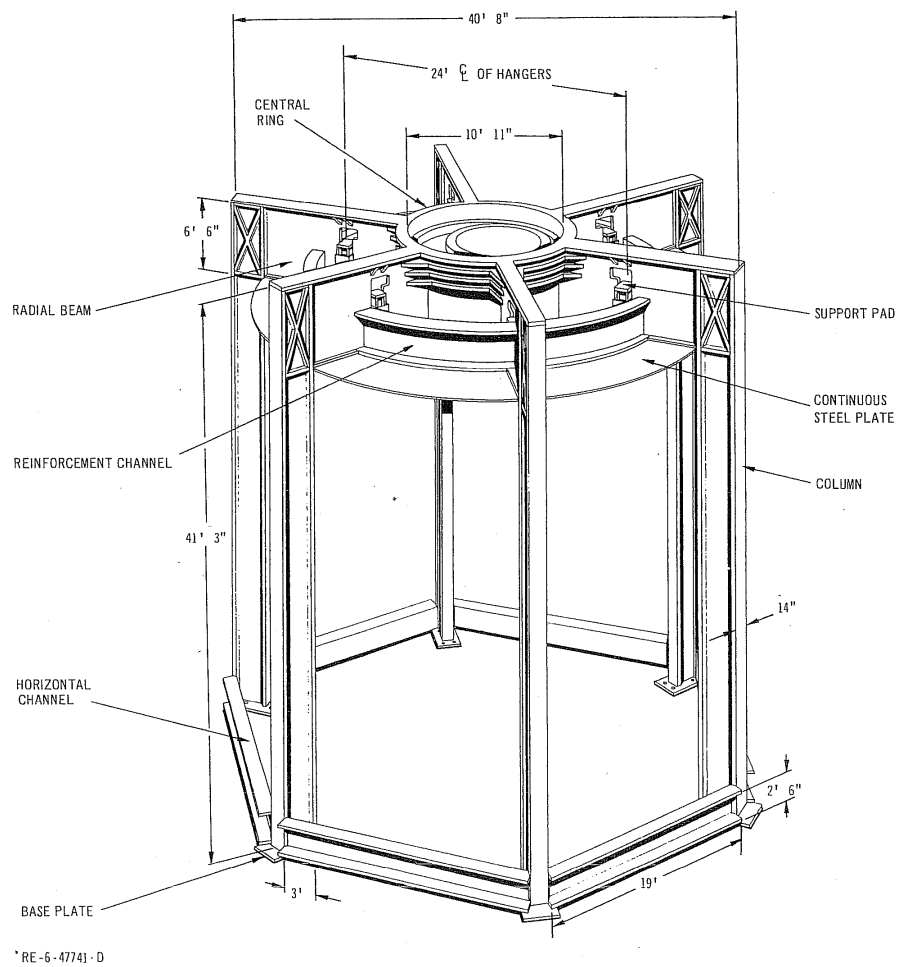

Figure 4.2-1 Primary Tank Support Structure

FIGURE 4

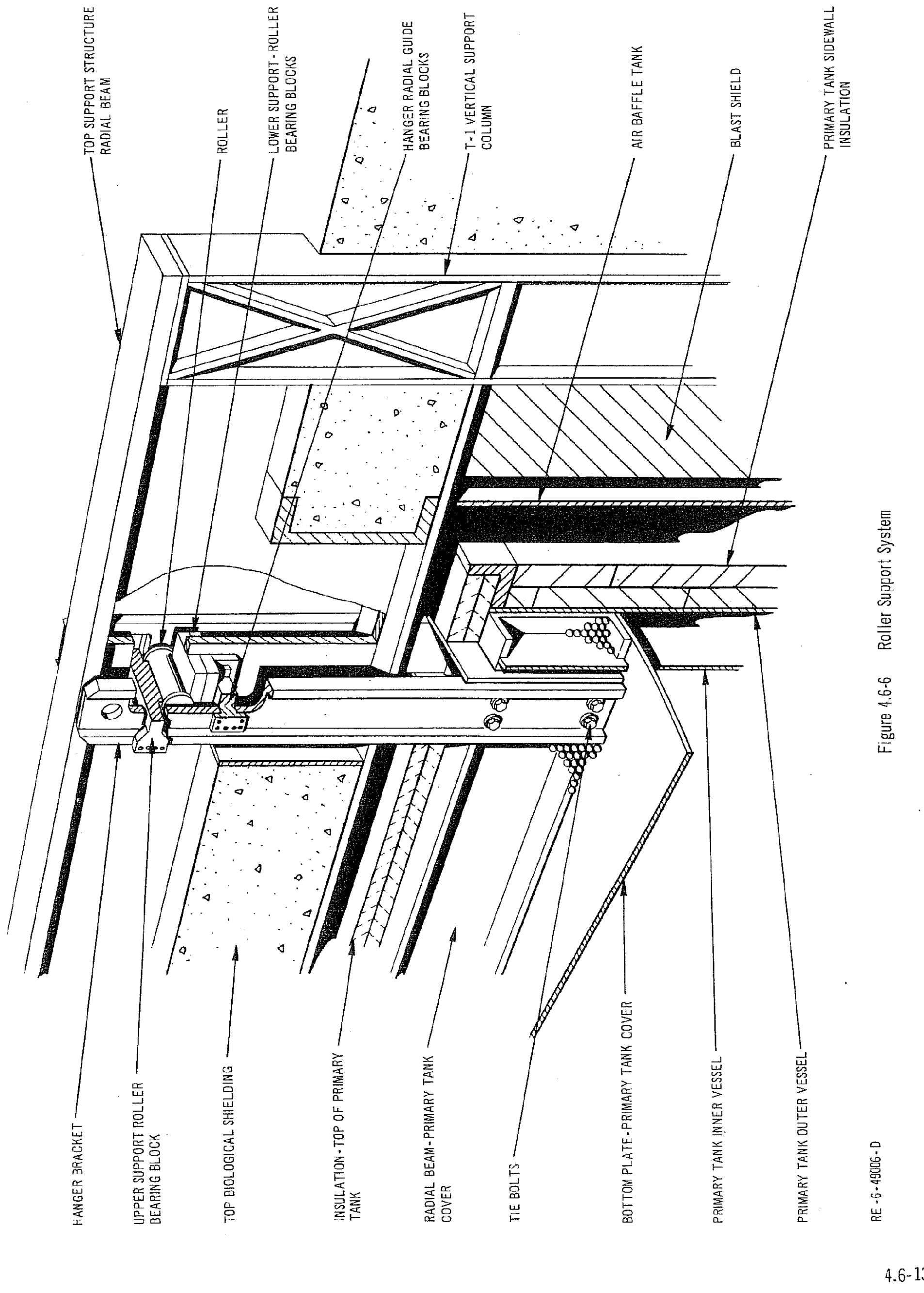

FIGURE 5

8. Demolish the Building Shell – The building shell would then be demolished using a combination of explosives, surgical demolition, and heavy equipment.

9. Evaluate the Footprint of the EBR-II Yard Area – The general area around the EBR II building shell structure is very congested with other operating structures, piping and buildings. There are many spatial constraints that would need to be overcome to accommodate the equipment required to lift the reactor. Assuming the lift would be accomplished by using a modular tower structure (See Step 13), the associated equipment would include the following components: two mobile cranes, 4 to 6 modular towers, and an area for the trailer footprint that would meet the appropriate compaction requirements. Additionally, the equipment may be restricted to stay approximately 15 ft away from any subgrade basement structures.

10. Site Preparations – Assuming the area could adequately accommodate the required equipment footprint several site preparations would need to be made prior to setup. The general area will need to be compacted to approximately 95% to provide a safe base for all mobile equipment. Modular tower foundations will need to be constructed for the towers erected on soil. The foundations could be constructed from concrete pads or steel plate. These foundations will provide the modular towers with a stable base for this magnitude of weight. However, if the distance between towers is too great and the span of the upper I-beam cannot handle the loading of the reactor package, one set of towers may need to be erected (or partially erected) on the first floor of the EBR-II building. An analysis of the floor would be required and shoring under the floor may be necessary. The loading effects on any subgrade basements would also need to be analyzed, and the walls shored as necessary or a restriction of approximately 15 ft put in place to keep the foundation walls from failing due to equipment loading. The effects on any subgrade utilities in the area will also need to be evaluated. The utilities may need to be protected or moved prior to equipment mobilization.

11. Mobilize Modular Towers, Transporter, and Equipment – In order to mobilize the equipment to the site the widths of the MFC security gates and the rout within MFC will need to be evaluated. It could potentially require 100 flatbed truckloads (or more) of components. Per Bigge Crane & Rigging Company, if a mobile crane were used this number could increase to hundred's truckloads. The turning radiuses, the underground utilities and the overhead utilities within MFC will need to be evaluated to accommodate these flatbeds. One option is to build a new dedicated road and security gate entrance on the west side of MFC. This road would allow access from the main road that traverses the west fence of MFC directly to the EBR-II reactor building area. Safeguards and security would need to be consulted to discuss the validity of this option. It is likely that multiple security systems would be affected by this modification. A large staging area within the MFC gates will be required to pre-stage all equipment prior to assembly. This area might be quite large due to the amount of equipment required for this lift. As of this date, no suitable location has been identified.

12. Equipment Setup – The physical assembly and setup of the modular towers will take one or two mobile cranes and up to two weeks of erection time. Wind restrictions during the setup will need to be continually monitored and may delay the progress of erection if wind speeds above 20 mph are experienced. The height of the modular

towers will need to be approximately 60 ft high to accommodate the height of the 39 ft tall primary vessel package, rigging and trailer.

13. Perform Lift – It is assumed that the lift will be performed using modular towers and strand jacks (See Figures 6 thru 8). Upon speaking with the rigging and lifting companies discussed in step 14, this seems like the most feasible option. There are mobile cranes that have the capacity to lift 1500 tons at our anticipated radius; however the mobilization, teardown and assembly of these cranes make them prohibitive. Per Bigge Crane & Rigging Company it would take hundred's of flat bed truck loads to mobilize a crane of this size (See Step 11).

    The modular towers use set in place lattice towers with runway beams mounted on top of the towers to lift and move the load, similar to an overhead building bridge crane. Alternatively, the tower bases can be mounted on runway tracks to facilitate moving the load to a transporter. However, for the EBR-II layout it is likely that 6 towers would be utilized in pairs with the first pair spanning across the reactor. The second pair would be placed between the reactor package and the transporter, and the third pair would span across the transporter. The reactor could then be lifted and moved down the runway and set on the transporter (See Figures 6 thru 8). The towers would be placed either on the soil adjacent to the EBR-II building containment or directly on the EBR-II building floor (See Step 10). Strand jacks are attached to the spreader beams and are used to lift the load (See Figure 9). The following associated tasks will need to be completed to perform the lift:

    13.1. Analyze the vessel shell for compression loads. The vessel shell will be approximately 40 ft high with the T-1 structure in place. A large portion of the vessel weight will be located in the upper portion of the structure, which consists of the primary cover, the upper bio-shield, and the T-1 structure, which will all be left intact during the lift. The inner primary tank wall is ½ inch thick steel, and the outer primary tank wall is ¼ inch thick steel. The inner primary tank will be filled with approximately 14 ft of grout. When the vessel is set on the transporter the thin wall of the outer primary containment must be evaluated to accommodate the compressive loads. The void space between the outer primary tank and the inner primary tank may need to be filled with grout to stiffen the structure. If this analysis proves inadequate a saddle could be designed to support the vessel on the transporter. Note: the vessel will not need to be analyzed for lifting loads since it was suspended during operation while containing 86,000 lbs of sodium. The total sodium weight is greater than the anticipated grout weight.

FIGURE 6

FIGURE 7

FIGURE 8

FIGURE 9, STRAND JACK

13.2. The vessel could be lifted from six points using the existing slot cutouts located in the web of the six radial I-beams (See Figure 5). The upper T-1 support structure was designed to support the weight of the suspended primary reactor vessel, the additional 3 ft 3 inches of high density concrete (that was later poured to form the upper bio-shield), and the weight of 86,000 gal of sodium. However the six lifting pick points (slots) that will be used were not specifically analyzed for lifting. A detailed model of the T-1 structure should be created to analyze the localized stresses induced from lifting from the slots.

13.3. A critical lift plan will need to be created. The lift would be classified as a critical lift per the CWI company MCP's and the DOE-STD-1090 hoisting and rigging standard. A detailed lift plan showing the lifting method, the required rigging, the layout of all equipment, the lifting capacities, load angles, etc.., would need to be created.

14. Transport – The following tasks are associated with transporting the vessel package:

14.1. Transporter dimensions and footprint: Three lift/ heavy haul companies were contacted to discuss the removal and transport of the EBR-II reactor. Southwest Industrial Rigging, Bigge Crane & Rigging Company, and Barnhart Crane & Rigging Company. In general, per these discussions, the biggest foreseen problem to overcome is the transport of the vessel package. The vessel package will need to be transported from MFC to ICDF over approximately 18 miles of state highway, plus 7 miles of site road.

In general DOT requires that any vehicle traversing over a state highway must meet the requirements of HS20 (AASHTO) truck loading, which is a maximum of 32000 lbs per axle. There are also additional axle spacing requirements for HS20 loading. This requirement is in place so as not to overload the asphalt, culverts, and bridges. It is assumed that the transporter will be required to meet these requirements, also it should be noted that many of the roads, and culverts on site were not designed to DOT standards. When transporting a vessel that weighs upwards of 1500 ton it will require distributing the loading over several axles and several wheels. The following writeup summarizes the information gathered from the rigging companies pertaining to transportation:

Southwest Rigging Company: Southwest Rigging did not have experience transporting a load of this magnitude over a public highway. Southwest however currently owns a Goldhoffer trailer. Per Southwest additional axles could be added to the Goldhoffer to make it 20 ft wide (double the normal width), and additional axles could be added to the length to make it as long as necessary to adequately distribute the load. The length of the trailer would need to be calculated based on the actual wheel loading. Southwest could not give an off hand estimate as to how long the Goldhoffer would need to be to accommodate this load.

Bigge Crane & Rigging Company: Per the Bigge representative Bigge has extensive experience moving loads of this magnitude. In their opinion the load should be maintained as low to the ground as possible, which is not achievable with a Goldhoffer trailer (termed a fixed platform type trailer). Bigge proposed using a beam and dolly transporter with a drop deck that would be 20 ft wide and up to 350 ft long. They currently have this type of transporter available. This would meet the HS20 truck loading requirement.

Barnhart Crane & Rigging Company: Per the Barnhart representative Barnhart also has extensive experience with moving heavy and large loads of this magnitude (See Figure 10 and 11). Barnhart's initial suggestion was similar to Southwest's suggestion to use a platform type trailer constructed in a 30 ft wide x 80 ft long configuration. Barnhart recommended using a 30 ft wide trailer for stability since the vessel will be 27 ft wide at the base. However Barnhart stated that this configuration still might not meet the required HS20 truck loading and would need to be evaluated. Barnhart also has beam and dolly type trailers available, however would not prefer to use them. Barnhart suggested that a one

FIGURE 10, BARNHART TRANSPORT

FIGURE 11

time exception to the HS20 truck loading might be obtained from the state that would allow the use a platform type trailer if the width of the trailer is maintained at 30 ft.

In summary, if a one time exception could be obtained from the state and a platform (Goldhoffer) type trailer can be used. The dimensions of this trailer would be between 20 to 30 ft wide, and 70 to 100 ft long. If a one time exception could not be obtained and the HS20 truck loading is enforced, a beam and dolly transporter could be used that would be 20 ft wide and up to 350 ft long.

14.2. Trailer Tie-Downs: The physical size and number of trailer tie-downs needed to transport this load will be considerable. Generally the equivalent working load limit of half the weight of the shipment in tie-down in working strength is required to be DOT compliant (See 49 CFR 173.106). An exception from the DOT requirement can be obtained through the preparation and approval of a transport plan. A tie-down analysis and sketch would need to accompany the transport plan.

14.3. Road out of MFC: The road width and travel path from EBR-II to the main MFC guard gate is riddled with buildings, sharp turns, overhead lines and underground utilities. For a transporter with the configuration discussed above it is likely that a new path will be needed to escape the confines of MFC. A new roadway could be constructed as previously discussed in step 11. This would provide direct access to the main MFC roadway and could be sloped and radiused as required to accommodate the size and dimensions of the transporter. A road design and analysis would be required. The new gate through the security fence would also have to be designed and constructed, and other existing security systems evaluated and possibly modified.

14.4. MFC to ICDF: All intersections from MFC to ICDF will need to be evaluated and will likely require widening to accommodate the turning radius of a 100 ft to 350 ft, 20 ft or 30 ft wide trailer. At the main junction from the MFC road to highway 26 state approval might be required to widen this intersection. The intersections would be widened by bringing in road base (3/4 minus crush) and compacting to 95% in approximately 6 inch lifts to widen the shoulders of the roads. A road design and analysis would be required. The MFC guard shack on the 4 mile stretch of road to highway 26 might also need to be widened or an additional road built around it to traverse the shack.

14.5. Evaluate Culverts: All culverts along the pathway from MFC to ICDF will require evaluation. If the HS20 truck loading is maintained this could simply be an evaluation. If the HS20 truck loading is not maintained, plate covers might be required to cover over the culverts in places where the analysis proves inadequate.

14.6. Overhead Obstructions: The height of all overhead obstructions would require evaluation. The vessel package could potentially be upwards of approximately 45 ft high. The overhead lines might need to be temporarily disconnected or relocated along the rout.

14.7. Transportation Plan: A transportation plan will be produced that identifies the requirements for hauling the vessel from MFC to ICDF. This will include: Road outage, overhead clearances, adequacy of culvert and bridge designs, width of roads, turning radius, security escort, etc. The convoy would travel less then 15 MPH. Therefore, consideration must be made for emergency vehicles and provisions if there is a malfunction with the transport vehicle and equipment.

15. ICDF Operations – The following tasks are associated with preparing the ICDF for acceptance of the vessel package:

15.1. Burm: The ICDF cell is surrounded by an approximate 20 ft high dirt burm which helps preserve the engineered lining within the cell. ICDF operations will be required to prepare a ramp on the wayward and leeward side of the burm to accommodate the transporter. There are two scenarios depending on what length of transporter is used. One, it is likely that a 350 ft long transporter would not be able to traverse the burm. Therefore a third lift of the vessel package might be required to swap transporters.

This lift would be performed in the ICDF lay down yard. The vessel would be lifted off of the primary 350 ft long transporter onto a secondary shorter platform type transporter that could safely traverse over the burm. The second scenario is assuming that the one time HS20 truck loading exception is obtained from the state and a platform type trailer can be used as the primary transporter. Per the rigging companies previously discussed in step 14.1, a large area tabletop would likely be required at the top of the burm to allow the platform trailer the ability to turn as required and distribute the loads on all wheels.

15.2. All equipment previously discussed in step 9 will need to be disassembled and re-mobilized to the ICDF site and re-assembled. The site preparations previously discussed in step10 will also need to be considered.

15.3. A second critical lift plan, showing the lift details, required rigging, and the transporter and modular tower location will be required for the lift at the ICDF.

15.4. The final vessel height within the ICDF cell will exceed the maximum cap height by approximately 12 1/2 feet. The final cap height of the disposal facility will need to be re-designed to accommodate this vessel height. There are two alternative options, one is to up-end the reactor and lay it down in the ICDF cell. To accomplish this the vessel package would need to be analyzed for up-ending stresses, and lower lift lugs would need to be analyzed, designed and installed on the vessel. However, the ends of the radial T-1 structural I-beams would still exceed the maximum height of the cell by approximately 14 ft, and would need to be cut off. The diameter of the T-1 structure is 40 ½ ft. The second alternative is to cut the T-1 structure and the primary tank lid off of the vessel package after final placement in the ICDF cell. This would require suspending the items with the crane or strand jacks as they are being cut. The items would then be moved to a separate location with in the cell.

16. De-Mobilization of Equipment – All equipment will be disassembled and temporarily staged for transport back to the rigging company. A large area at ICDF will be required for this evolution.

Conclusion

The technical feasibility of the two options for disposal of the EBR-II reactor have been evaluated. Both options pose challenges that are unique to the INEL. The first option explores the feasibility of removing the reactor vessel exclusive of the primary tank. This option would require disassembling the primary components in the reverse sequence as assembled to remove the reactor vessel. This involves removing components, cutting piping, disconnecting bolts, and cutting welds from around the base of the reactor vessel, while remotely working within the primary tank. Because of the high dose rates and the limited penetrations in the primary lid and the T-1 structure this option poses many technical challenges that may not be feasible. Additionally, since the reactor vessel components were assembled inside the inner primary tank, the reactor vessel would need to be rigged and lifted out of the T-1 structure rotating plug opening, which is dimensionally infeasible.

The second option explores the feasibility of removing the reactor vessel inclusive of the primary tank. This option would break the T-1 structure radial beams out of the bio-shield, and lift the entire vessel package including the T-1 structure radial arms, the upper bio-shield concrete, the primary lid and shielding, the inner and outer primary tank and all components within the primary tank. The total vessel package would weigh approximately 1500 tons. Due to the configuration of the vessel this option is feasible; however, several technical challenges would need to be overcome to accomplish this task. The transportation from MFC to the ICDF would be the main difficulty due to the weight of the reactor package and the size of the transport trailer.